PLANT RESPONSE TO NITROGEN FROM THREE SLOW RELEASE FERTILIZERS

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BY

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PURDUE UNIVERSITY AND

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Interim Report

PLANT RESPONSE TO NITROGEN FROM THREE SLOW RELEASE FERTILIZERS

TO: J. F. McLaughlin, Director
Joint Highway Research Project

June 22, 1972

Project: C-36-48C

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 9-5-3

The attached report is another Interim Report on Part II of the HPR research study "Research in Roadside Development and Maintenance". This one "Plant Response to Nitrogen from Three Slow Release Fertilizers" reports additional research on "Selection, Establishment and Maintenance of Woody Ornamentals for Highway Plantings". Messrs. R. E. NcNiel and P. L. Carpenter have authored this report.

Although the results indicate some possible benefit from using slow release nitrogen fertilizers for highway landscape plants, the findings do not warrant any change in Indiana specifications for plantings at this time. The nitrogen uptake response was very limited and additional research is required on rates, placement, and longevity and total effects on plant hardiness.

The Report will be presented to the ISHC and FHWA for review, comment and acceptance. It is presented to the Board for acceptance as partial fulfillment of the objectives of the study.

Respectfully submitted,

Harold L. Michael

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by

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Joint Highway Researc Project
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REVIEW OF LITERATURE

An additional fertility program is needed to ensure plant life on minimal fertility soils. This type of soil, in the form of parent material and subsoil, is left on the surface when highways are built. When a soil is depleted of nutrients and becomes dependent on fertilization, the total benefit and life span of fertilizers are important.

Meyer (8) explained how nutrient supplies during the preceding year and current spring were important to shoot growth and leaf production. He also reported (9,10) nitrogen reserves seemed to be the limiting factor on both a deciduous and an evergreen species

In supplying nitrogen with a common water soluble fertilizer, several applications are needed annually to provide an adequate supply. Several applications become expensive and thus a method of making fewer applications of fertilizer while supplying adequate nitrogen would be beneficial in reducing the labor costs.

Nitrogen losses of 40% may occur with common fertilizers (12). The principal loss is due to the nitrate ion being quite soluble and thus readily leaches from the soil. With ammonium fertilizers an additional loss comes from the ammonium ion being volatilized from the soil surface. The ammonium ion is most susceptible to being lost in the first seven days after being formed. Nitrates

in turn will remain until leached by rain (12).

Due to these losses, research during the past decade has produced several fertilizers that release nitrogen slowly or at a rate similar to the needs of the plant. Three fertilizers urea-formaldehyde (U-F)[1], magnesium ammonium phosphate (MgAP)[2], and isobutylidene diurea (IBDU)[3] were used. From each nitrogen is released by either a slow rate of dissolution or by susceptibility to microbial decomposition (11). By using the slow release fertilizers the losses would be reduced and the nitrogen used more efficiently.

U-F depends on the method of manufacture and the ratio of urea to formaldehyde for slow release. For these reasons, U-F can range from completely soluble to insoluble. The manufacturer claimed that U-F was thirteen per cent water insoluble and classified (by A.O.A.C. standards) with an activity index of 40 or more (1). The insoluble product is decomposed and mineralized by microbial activity.

Because of a low solubility rate and a slow rate of achieving saturation (about 1.7 meq. per liter), MgAP is resistant to being leached from the soil (4). As MgAP dissolves, nitrification becomes

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1/ Agriform with an analysis of 20-10-5 was manufactured by Agriform International Chemicals, Inc., Newark, California.

2/ MagAmp with an analysis of 7-40-6 was manufactured by W. R. Grace & Co., Baltimore, Maryland.

3/ IBDU with an analysis of 32-0-0 was supplied by Swift and Company Oak Brook, Illinois.

important as the ammonia form is changed to nitrate (4). Thus the nitrogen does not volatilize and is readily available for uptake by the plant.

IBDU releases nitrogen slowly due to a low solubility (0.1-0.01 g. per 100 ml) caused by the strength and size of the particle (2). Microbial activity does not influence the rate of dissolution but this activity does influence mineralization of nitrogen to a form available to a plant (4).

These fertilizers are known to last more than one year (1,5,6), however, it is not known how long plants can continue to benefit from each fertilizer or at what rate they will be most beneficial.

MATERIALS AND METHODS

A field plot was established on a loamy fine sand at the Maxwell tract of the Horticulture Park, Purdue University, Lafayette. The soil analysis [4/] listed a pH of 6.9 with 3.0 ppm nitrate, 24.7 kg/hectare phosphorus and 42 kg/hectare potassium.

With each of the three fertilizers used, large particle size and the slow release of nitrogen (2,4,8). The largest available particle size was used with all fertilizers. U-F and MgAP were commercial grades while the IBDU was a custom research granule. U-F was a

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[4/] Soil Testing Laboratory, Agronomy Dept., Purdue University, Lafayette, Indiana.

tablet with a weight of 21 grams. MgAP and IBDU were both granules with MgAP varing in weight from -05 gram to .75 gram and with the IBDU granule being one gram in weight.

Treatments consisted of U-F with 1, 2, and 4 tablets (4.2, 8.4, and 16.8 grams of N added); MgAP with 56.7, 113.4, 226.8, and 453.6 grams of granules (4.0, 7.9, 15.9, and 31.8 grams of N added); and IBDU with 14.2, 28.4, and 56.7 grams of granular fertilizer (4.5, 9.1, and 18.2 grams of N added). The two treatments used for control were plants without additional fertilizer. Plants from one control were originally intended to be used with a water soluble fertilizer treatment. At that time equipment was not available to apply the fertilizer as stated in highway recommendations. Treatments of three plants each were randomized in a complete block design with four replications.

Plants treated were _Cotoneaster divaricata_ Rehd. + Wils. and _Juniperus chinensis pfitzeriana_ Spaeth. which were grown in 20 cm diameter metal containers for two years prior to transplanting in May 1970.

Prior to the distribution of the fertilizer, a uniformly augered hole was adjusted so that it was 6-8 cm deeper than the expected placement of the soil ball. With one exception, the granular fertilizers were evenly distributed on the bottom of the hole. After placement of the fertilizer, 6-8 cm of soil was added to the hole before planting. The exception was with the 453.6 grams of

MgAP which was incorporated into two cubic feet of soil and then backfilled around the entire soil ball. When tablets of U-F were used, the hole was backfilled half way up the soil ball, and then the tablets were placed in the hole 6-8 cm from the side of the soil ball. The two tablets were placed on opposite sides of the hole and the four tablets were spaced evenly around the hole.

Tissue samples for nitrogen analysis were taken September 29, 1970; May 29, 1971; June 16, 1971; and September 27, 1971 by removing 8-10 cm of terminal growth from approximately twelve branches among the three plants per treatment. Samples were dried at 80° C in excess of 24 hours before being ground in a mill until the dried sample would pass through a 40 mesh sieve.

Total nitrogen analysis was with the micro-kjeldahl and steam-distillation method using a salicylic acid modification described by Bremner (7).

RESULTS

Nitrogen content of the foliage was expected to be highest in the spring when growth was the greatest. No response occurred with treatments on _J. chinensis pfitzeriana_ (Table 1, Table 2, and Table 3). Horizontal root growth above the fertilizer band may be the reason for no differences in nutrient uptake. _C. divaricata_ had the nitrogen content of its foliage increased during the second season when treated

with each fertilizer.

No plants were sampled on September 27, 1971 where MgAP at the 453.6 g. rate was applied to C. divaricata, nor were J. chinensis pfitzeriana plants sampled on June 16, 1971 or September 27, 1971 where MgAP was applied at 543.6 g. because plants were dead or missing. Two plant pathologists (R. J. Green and D. H. Scott, Purdue University) confirmed that death of C. divaricata tissue was not caused by disease. All plants had formed normal growth for several weeks before each plant developed dead tissue. Only plants treated with 453.6 grams of MgAP were eventually killed. An explanation for the injury is that Cotoneaster roots are sensitive to low temperatures. Havis (3) has found C. horizontalis roots were killed at -7.8^{o} C. A temperature of -8.8^{o} C at a 20 cm. depth was recorded at the Agronomy Farm, Purdue University, Lafayette (Figure 1). It is not known if the missing J. chinensis pfitzeriana plants were killed by disease, etc. Vandalism is a possible reason for the loss.

On May 29, 1971 the foliage of C. divaricata contained significantly higher quantities of nitrogen in plants treated with four tablets of U-F, 226.8 and 453.6 g of MgAP, and the 28.4 and 56.8 g of IBDU as compared with the control plants (Table 1, Table 2, Table 3). On June 16, 1971 the foliage of C. divaricata contained significantly higher quantities of nitrogen in plants treated with two and four tablets of U-F, 226.8 and 453.6 g of MgAP, and 56.8 g of IBDU as

compared with the control plants (Table 1, Table 2, and Table 3). With either fall sampling date, the foliage of _C. divaricata_ contained no significantly different quantities of nitrogen when compared to the control plants. Plants treated with four tablets of U-F, 56.7 g. of IBDU, and 226.8 g. of MgAP contained more nitrogen in the foliage as compared to all other treatments on May 29, 1971 and June 16, 1971. However, there was no significant difference among these three treatments during the spring and summer of 1971 (Table 4).

Plants treated with 453.6 g. of MgAP contained twice as much nitrogen in the foliage as did the plants treated with the three rates mentioned above on the May 29, 1971 sampling date while only equal to them on the June 16, 1971 sampling date.

CONCLUSIONS AND PRACTICAL APPLICATIONS

The results of the initial studies suggest that the use of slow release nitrogen fertilizers may be of some benefit as a nutrient source for highway landscape plants. However, the growth and nitrogen uptake response was so limited that additional research should be carried out on highway sites before recommending changing specifications for planting on Indiana highways. This additional work should be initiated during the summer of FY 1972-73. Additional information should be obtained on rates, placement, longevity and total effects on plant hardiness.

Table 1. Plant nitrogen content from urea-formaldehyde fertilizer.[z]

Treatment	Species and date of foliage collection							
	Cotoneaster divaricata				*Juniperus chinensis pfitzeriana*			
	9-19-71	5-29-71	6-16-71	9-27-71	9-29-70	5-29-70	6-16-71	9-27-71
	ppm nitrogen x 10^{-3}							
Control	24.9cb	28.7c	20.0b	28.1b	17.9a	20.1a	24.4a	23.8ab
Control	23.2ac	29.6bc	20.4b	26.8ab	1/.9a	21.4a	23.3a	23.2a
Urea-formaldehyde, 1 tablet	22.1a	29.8bc	21.1b	26.6ab	17.3a	19.4a	26.0a	23.6ab
Urea-formaldehyde, 2 tablets	24.2cb	30.5b	24.2a	24.3a	17.3a	21.0a	24.7a	25.1b
Urea-formaldehyde, 4 tablets	25.8b	32.2a	23.4a	27.8b	17.9a	20.1a	23.0a	24.9ab

[z]Means in each column with different letter differ at the 5% level.

Table 2. **Plant nitrogen content from magnesium ammonium phosphate fertilizer.**[z]

Treatment	Species and date of foliage collection							
	Cotoneaster divaricata				*Juniperus chinensis pfitzeriana*			
	9-29-70	5-29-71	6-16-71	9-27-71	9-29-71	5-29-71	6-16-71	9-27-71
				ppm nitrogen x 10^{-3}				
Control	24.9ab	28.7b	20.0a	28.1ab	17.9ab	20.1ab	24.4a	24.8a
Control	23.2b	29.6bc	20.4ab	26.8ab	17.9ab	21.4ac	23.3a	23.2a
$MgNH_4PO_4 \cdot H_2O$, 56.7 grams	23.5b	30.0bc	22.6cd	27.5ab	16.7a	18.7b	22.9a	22.9a
$MgNH_4PO_4 \cdot H_2O$, 113.4 grams	24.5ab	30.4c	22.0bd	24.3a	18.2ab	22.3cd	23.2a	24.4a
$MgNH_4PO_4 \cdot H_2O$, 226.8 grams	25.7ab	32.9a	23.9c	28.5b	19.0b	23.9d	25.2a	25.0a
$MgNH_4PO_4 \cdot H_2O$, 453.6 grams	26.2a	33.9a	23.2cd	--	19.3b	22.9cd	--	--

[z] Means in each column with different letters differ at the 5% level.

Table 3. **Plant** nitrogen content from isobutylidene diurea fertilizer. [z]

Treatment	Species and date of foliage collection							
	Cotoneaster divaricata				*Juniperus chinensis pfitzeriana*			
	9-29-70	5-29-71	6-16-71	9-27-71	9-29-70	5-29-71	6-16-71	9-27-71
	ppm nitrogen x 10^{-3}							
Control	24.9ab	28.7c	20.0b	28.1a	17.9a	20.1a	24.4a	23.8a
Control	23.2a	29.6cd	20.4b	26.8a	17.9a	21.4ab	23.3a	23.2a
Isobutylidene diurea, 14.2 gram	25.1ab	30.3b	21.5b	29.0a	17.0a	22.8b	24.8a	24.9a
Isobutylidene diurea, 28.4 gram	24.2ab	31.1b	22.0b	25.8a	16.5a	21.7ab	23.9a	24.8a
Isobutylidend diurea, 56.7 gram	25.8b	32.4a	24.6a	28.9a	17.4a	21.9ab	24.0a	24.7a

[z] Means in each column with different letters differ at the 5% level.

Table 4. Nitrogen content of plants supplied with three slow release nitrogen fertilizers.[z]

Treatment	Species and date of foliage collection							
	Cotoneaster divaricata				*Juniperus chinensis pfitzeriana*			
	9-29-70	5-29-71	6-16-71	9-27-71	9-29-70	5-29-71	6-16-71	9-27-71
	ppm nitrogen x 10^{-3}							
Control	24.9cb	28.7c	20.0b	28.1b	17.9a	20.1a	24.4a	23.8ab
Control	23.2ac	29.6bc	20.4b	26.4b	17.9a	21.4a	23.3a	23.2a
Urea-formaldehyde, 4 tablets	25.8b	32.2b	23.4b	27.8a	17.9ab	20.1a	23.0a	24.9a
Isobutylidene diurea, 56.7 gr ms	25.8b	32.4b	24.6b	28.9a	17.4a	21.9ab	24.0a	24.7a
$MgNH_4PO_4 \cdot H_2O$, 226.8 grams	25.7b	32.9ab	24.0b	28.5a	19.0ab	23.0b	25.2a	25.0a
$MgNH_4PO_4 \cdot H_2O$, 453.6 grams	26.2b	33.9a	23.2b	--	19.3b	22.2b	--	--

[z] Means in each column with different letters differ at the 5% level.

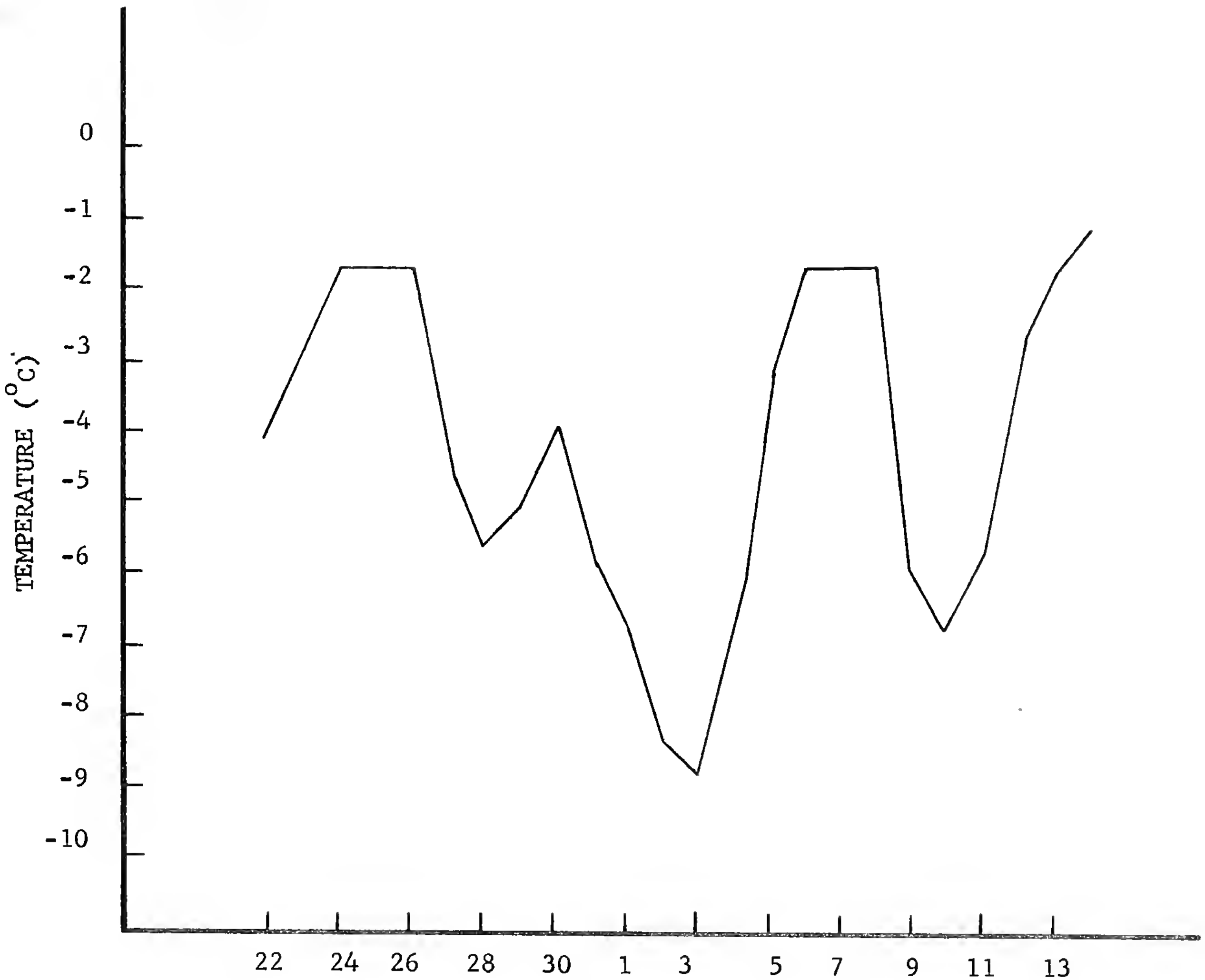

Figure 1. Temperatures recorded at a 20 cm depth between January 22, 1971 and February 14, 1971 at the Indiana Climalogical Station: West Lafayette 6 NW.

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